

to prevent the expulsion of the oil when the capillary action which retains it is overcome. In cases where there is no flange, the pressure on the unit of surface of the cone will have to exceed that on the head for the same reason, and if the necessary relief cannot be given with the given dimensions of the axis, it can of course in this case be attained by increasing its dimensions.

“How far attention to these principles will secure stability in conjunction with freedom of motion, it is impossible to say without putting them in practice, but I hope soon to have an opportunity of carrying them out in endeavouring to obtain a better azimuthal motion for one of the 3-foot vertical circles belonging to the trigonometrical survey of India, which, though producing results of the highest order, would still admit of an improvement. I am induced to offer these remarks to the Society, in the hope that the hydraulic relief may be an improvement on those previously in use, and that by it a class of instruments in which I am professionally much interested may be rendered more perfect.

“I have not attempted to lay down any rules as to the dimensions of axes or their forms. So many variables are involved in the determination of the best form, and a departure from it to a moderate extent will so little affect the value of instruments, that probably no definite rules could be so valuable as the intuitive perception of the practised artist. I believe, however, the general principles I have here laid down, and the theory to guide their application, will occasionally be found useful, and they may tend to place the form of instrument preferred by Mr. Troughton on equal terms with that chosen by some other makers, by increasing the steadiness without the disadvantage of unequal expansions inseparable probably from the framework required to support an axis at both extremities.

“In the case of the 3-foot circle I propose that the drum pillars and micrometer-supporters should be cast in one piece of iron, and, after being fitted, adjusted so as to have the centre of gravity axial by floating the mass in mercury, and adding or subtracting small weights of metal, as may appear desirable.

“*Masuri, June 4, 1856.*”

Notes on the Manufacture of Tubes for Refracting Telescopes.
By Frederick Brodie, Esq.

“In the early part of this year I parted with my Munich refractor of $6\frac{1}{2}$ inches clear aperture, and obtained from the Rev. W. R. Dawes his American object-glass, made by Mr. Alvan Clarke, of Boston, U. S., an account of which was published in the *Monthly Notices*, vol. xv. page 79.

“The original tube for this glass was retained by Mr. Dawes for mounting another larger object-glass, by the same maker. It,

therefore, became a matter of consideration with me to procure a tube which should combine strength, rigidity, and lightness, being convinced in my own mind, that the less the weight of the tube (and consequently of its counterbalances), the greater would be the steadiness and freedom from vibration when mounted on its equatorial stand.

"I was led to this conclusion by the experience which I had had with my $8\frac{1}{2}$ -foot Munich refractor, with its light wooden tube, and in which, when fixed on my peculiar equatorial mounting, I had never found the slightest oscillation or tremor, when moved either by hand or the tangent-screw motion. This great steadiness I attribute to two principal causes:—Firstly, to the loading of the polar axis with as little weight as possible. Secondly, to the fact that the polar axis has comparatively large bearings.* In several mountings of large telescopes that I have seen, where the polar axes have been loaded with brass tubes and heavy circles, and where the bearings (or pivots) have been comparatively small, I have noticed a very considerable amount of oscillation in right ascension.

"After some consideration I determined on constructing the tubes entirely of mahogany veneers; veneers cut from deal would have been lighter than those from mahogany, but they were not considered so trustworthy for this purpose. I placed the execution of this experimental tube in the hands of Mr. Chaffins, of 67 Oxford Street, who carried out my directions satisfactorily.

"This tube was formed upon a core of dry, well-seasoned deal planks, and turned down in the lathe to the following dimensions:—

Length of core	.....	9 ft.	0 in.
Diameter, large end	.....	.....	$7\frac{7}{8}$
Do. small end	.....	.....	$5\frac{7}{8}$

"The core was well soaped to prevent the possibility of any portion of glue adhering to it, and thereby rendering the removal of the tube difficult when finished. Upon the core a sheet of thick brown paper was wrapped, its edges being pasted together, to serve as a foundation for the first veneer. The core was then brushed over with glue, and a veneer of mahogany laid round it; a moveable caul made of double canvas was then laid round the veneer, and drawn up tightly by means of screws.

"This caul exactly fitted the taper of the tube, and its longitudinal edges were securely fastened to two strips of wood. In one of these strips, at intervals of about 5 inches, were inserted common bed-screws, moving freely through it, and screwing into

* The size of the bearings of the polar axis cited above was as follows:—

Lower bearing	.....	4 inches diameter.
Upper do.	.....	$3\frac{1}{4}$ do.

corresponding nuts in the other strip. By this means the caul was screwed up tightly round the veneer, thereby ensuring a close contact between it and the core.

"The core was then placed over a stove-pipe, which extended along its whole length, and was slowly turned on its axis until it became sufficiently hot to melt the glue, which thus became equalized, while the superabundant quantity was squeezed out; a portion even permeating the veneer, owing to the pressure of the caul. The core was then set aside for two or three days to dry.

"Every successive veneer, prior to being laid on, was lined with a piece of thin calico, to prevent the veneer from splitting while being turned round the core. This calico was removed when the veneer was dry; after which the surface was prepared for another veneer, by being levelled over and freed from inequalities by the veneer plane. Each veneer was in a single piece, the joints being placed at alternate sides of the tube, and the grain of the wood was reversed at every layer. A tube was thus formed of eight thicknesses, the seven interior ones being of Spanish mahogany having stains or other faults which rendered them unfit for *fine* cabinet work, and therefore of moderate cost (about 9d. per foot super). The eighth was of the finest Spanish mahogany, and cost (on account of its great size) about 1s. 8d. per foot super. The thickness of tube when finished was $\frac{3}{8}$ of an inch. It was French polished on the outside.

"Since this tube has been finished another tube has been constructed in a similar manner, and sufficiently stiff, of only *six* veneers. The dimensions being,

Length of tube	.....	.....	6 ft. 8 in.
Inside diameter, large end	.....	.....	$6\frac{2}{3}$
Do. small end	.....	.....	$4\frac{3}{4}$

"The tube which was sent over from America by Mr. Alvan Clarke is of a novel construction, it being made of a sheet of zinc covered with brown paper. This tube is still in the possession of Mr. Dawes, and carries an 8-inch object-glass. It is only $\frac{2}{10}$ ths of an inch in thickness, but is remarkably solid and hard to the touch.

"The method of making these tubes is thus described by Mr. Clarke in a letter to the Rev. W. R. Dawes:—

"We made our tube for that (telescope), as we have for others since, of thin tin, overlaid with paper and paste, to a suitable thickness. By drawing a thread from end to end we find out the low parts, and raise them by an extra coat of paper, and at the same time rasp down the higher parts until tolerably straight. We then joint a piece of plank and coat it with wax, and lay sand-paper upon it; with this we dress down the tube preparatory to painting. We give several coats of different tints, blue, red, and yellow, all faint, but of the same depth when dry; they are rubbed down together. The effect is very pleasing to the eye, and I think, under

copal varnish, this tube must be very secure. For the larger object-glass which you have, zinc was used instead of tinned iron.'

"The Munich tubes appear to be made of two thicknesses of light wooden battens, about $2\frac{1}{2}$ inches wide, and of the same length as the tube itself. These battens are laid longitudinally round a core, the inner thickness breaking joint with the outer; over this is laid a veneer of mahogany, which is finally French polished.

"The relative weights and thicknesses of the different tubes are as follows:—

	Thickness of Tube.	Weight of Tube.	
		lbs.	oz.
Brass or iron tube	0.06 to 0.10	3	to 5 lbs.
Square deal, corners champered off	1.00	2	8
American tube, paper and zinc	0.20	1	10 $\frac{1}{2}$
Mahogany tube, 8 veneers thick	0.37	2	1
Do. 6 veneers thick	0.28	1	8 $\frac{1}{2}$ "

Specimens of the tubes described accompanied the paper.

On the Angular Disturbances of Ships, as affecting Astronomical Observation at Sea. By Professor C. Piazzzi Smyth, F.R.S.E.,
Astronomer Royal for Scotland.*

"Every one who has used a telescope on shore knows the importance of steadiness in its stand; and nearly every one in this nautical country must have experienced in person how ships roll, and pitch, and lurch at sea; upsetting all ideas of stability, even for the ordinary affairs of life, and much more for scientific requirements. On inquiring, however, from even practical men, I have not found them able to give me numerical particulars of the exact amount, and the manner of the occurrence, of these angular disturbances of position, which occur to a ship while pursuing its onward course; and as some knowledge of this is essential before attempting to devise a remedy, we may with propriety first consider the means of obtaining this information.

"*Measurement of the Disturbances.*—All the various angular motions to which any ship is liable, the translation of the whole ship bodily being of no moment here, are reducible to three, viz., —to *rolling*, a motion from side to side; *pitching*, from end to end; and *yawing*, or deviating in azimuth.

"*Old Ship-Clinometers.*—Very ingenious methods have been contrived to fit pendulums to act as ship-clinometers, as in Captain Becher's horizon; wherein the pendulum swings in a vessel of oil. But the result is not satisfactory; for the oil itself is dis-

* Reduced, by permission, from a paper lately presented to the Society of Arts at Edinburgh. The woodcuts have been very kindly lent by the Society.